

# **An Evaluation of Composites Fabricated from Powder Epoxy Towpreg**

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## **Abstract**

BASF has developed a unique process for applying powdered resin systems to continuous reinforcement fibers in order to produce flexible towpreg material. Evaluation of three powder epoxy resins by BASF using this towpregging process is in progress under NASA contract NAS1-18834. Shell RSS-1952, Dow CET-3, and 3M PR500 powder epoxy systems have been successfully towpregged with G30-500 6K carbon fiber. Both neat resin and basic unidirectional composite properties have been developed to compare performance. Cure cycles for each system have also been developed for repeatable fabrication of high-quality composite laminates. Evaluations of the powder towpreg material for use in textiles processes such as weaving and braiding are underway. Traditional 8-harness weaving has been successfully performed with one system (PR500/G30-500) to date, with some basic composite properties generated. Ongoing work will demonstrate scaleup of the towpregging process for higher throughput, as well as evaluation of the powder towpreg material in advanced preforming processes such as 3-D braiding and weaving.

## **POWDER EPOXY TOWPREG DEVELOPMENT**

- NASA Contract/Materials Characterization
- Primary Focus Subsonic Applications (180°F Service)
- Evaluate Mechanical Performance
- Evaluate Use in Textiles Preforming
- Evaluate Manufacturing/Processing Methods

## **ADVANTAGES OF "DRY" MATERIAL FORMS**

- Conformability
- Textile Yarn Form/Textile Technology Applications
- No Refrigeration Required

## **POWDER EPOXY TOW ADVANTAGES**

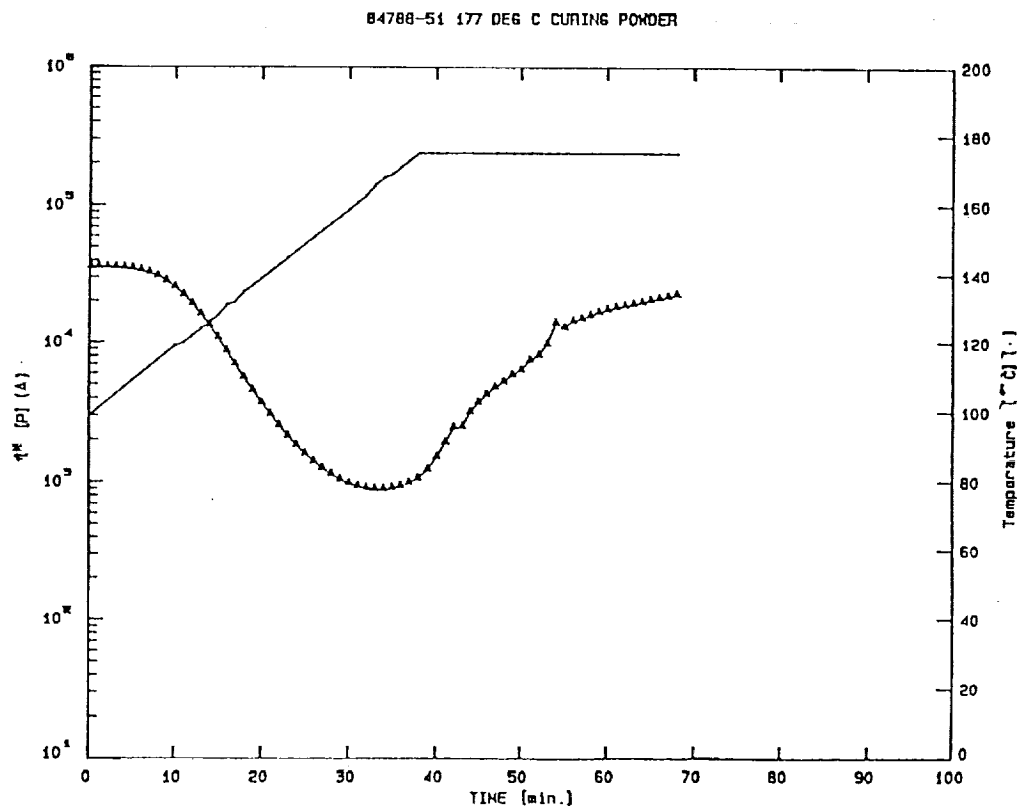
- Predetermined Fiber Volume
- "Predetermined" Chemistry
- Good Fiber/Resin Distribution
- No Solvents
- Room Temperature Storage

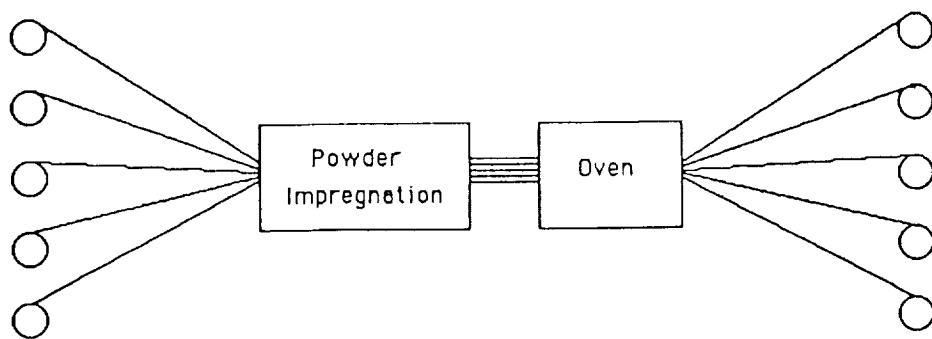
## **CANDIDATE POWDER EPOXY SYSTEMS**

- PR-500 (3M)
- RSS-1952 (SHELL CHEMICAL)
- CET-3 (DOW CHEMICAL)

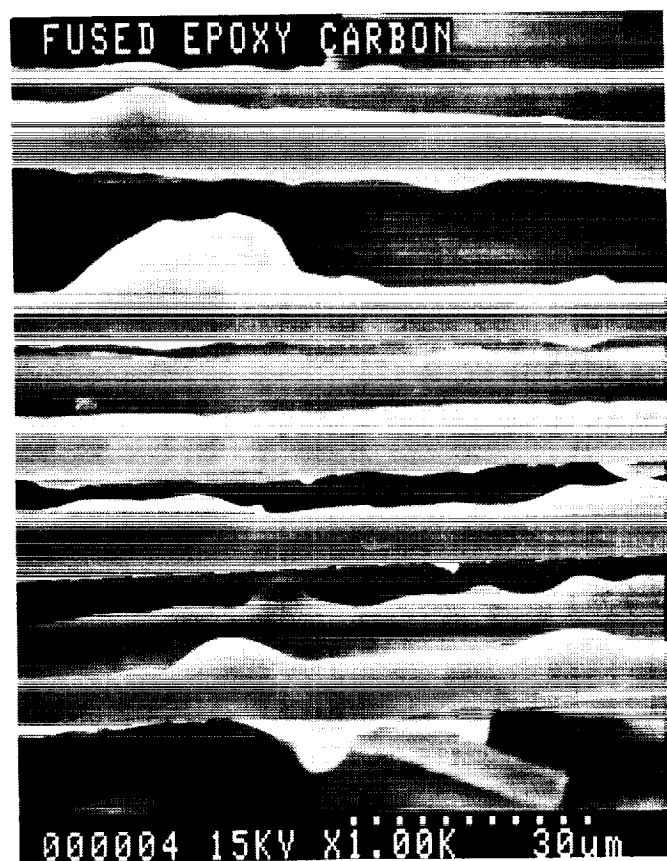
# PHYSICAL PROPERTIES, NEAT RESIN

	PR-500 (3M)	RSS-1952 (SHELL)	CET-3P (DOW)
Tg (DSC, °C/°F)	205/401	219/426	164/327
TENSILE STRENGTH (KSI)	8.3		13.0
MODULUS (KSI)	507		410
ELONGATION (%)	1.9		5.0
FLEXURAL STRENGTH (KSI)	18.4	16.9	21.0
MODULUS (KSI)	504	426	450
STRAIN (%)	4.2	5.1	7.0
DENSITY (gm/cc)	1.25	1.15	1.27
MOISTURE ABSORPTION (% WT.)	1.56	1.1	1.35





Schematic, Powder Coating Process



Powder Coated Tow, 1000X

## CURE CYCLE, FUSED TOWPREG

PR-500 (3M): 350°F/2 hours

RSS-1952 (Shell): 300°F/2 hours, ramp to 400°F/4 hours

CET-3P (Dow): 300°F/4 hours; 400°F/4 hour post-cure

## COMPOSITE PROPERTIES, UNIDIRECTIONAL TOW

	<u>PR-500/G30-500</u>	<u>RSS-1952/G30-500</u>
FIBER VOLUME	55%	63%
<u>0° 3 PT. FLEXURE (RT, 32-1)</u>		
STRENGTH (KSI)	242	320
MODULUS (MSI)	16	19
<u>0° 4 PT. SHEAR (RT, 16-1)</u>		
STRENGTH (KSI)	12.2	10.0
<u>90° 3 PT. FLEXURE (RT)</u>		
STRENGTH (KSI)	11.0	9.0
MODULUS (MSI)	1.2	1.18

# PHYSICAL PROPERTIES, 8-HARNESS FABRIC

RESIN: PR-500 (3M)

FIBER VOLUME: 56%

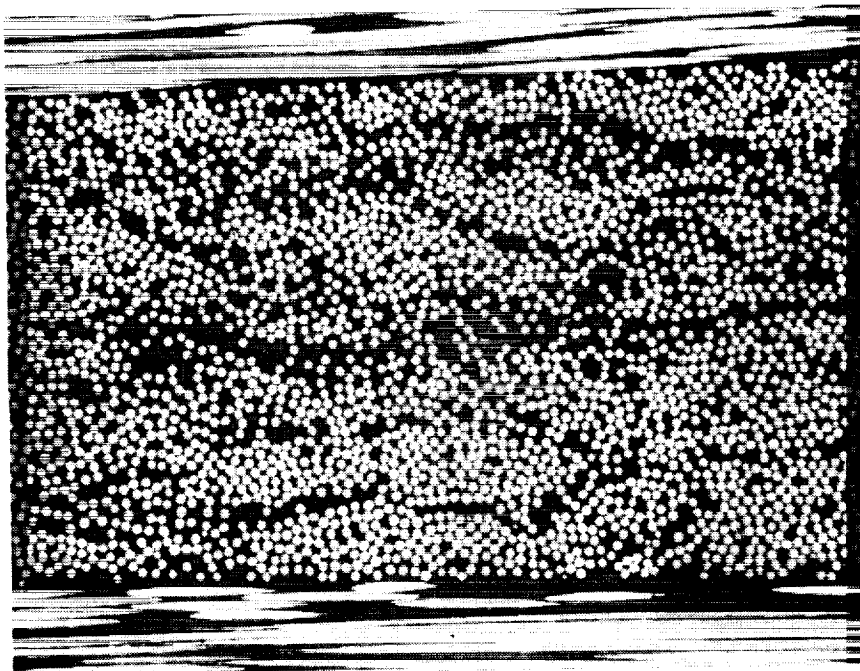
## 3 PT. FLEXURE (RT. 32-1)

STRENGTH (KSI) 102.0

MODULUS (MSI) 7.1

## 4 PT. SHEAR (RT. 16-1)

STRENGTH (KSI) 6.0



Photomicrograph, Cured 8 Harness Laminate

## **CONCLUSIONS/ACCOMPLISHMENTS**

- Fused Towpreg Approach Is Viable With Powder Epoxy
- 5-Ends Successfully Demonstrated
- Fused Epoxy Tow Is Weaveable Using Standard Techniques
- Good Fiber/Resin Distribution and Wet-Out Demonstrated
- Initial Unidirectional and 8-Harness Data Generated

## **FUTURE PLANS**

- Generate RSS-1952 and CET-3 8-Harness Fabric Data
- Complete RT and Hot/Wet Mechanical Testing
- Determine Processing Window
- Verify Preforming Feasibility (2-D and 3-D)
- Develop De-bulking and Part-Manufacturing Methods



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